

EXPERIMENTAL INVESTIGATION ON STRAIGHT THROUGH SOLAR SALT WATER DESALINATION SYSTEM ANALYSIS IN DIFFERENT PCM MATERIALS

M. RUBAN¹, S. SIVAGANESAN² & C. DHANASEKARAN³

¹Assistant Professor, Vels University, Chennai, Tamil Nadu, India

^{2,3}Associate professor, Vels University, Chennai, Tamil Nadu, India

ABSTRACT

The research maximizes the level of use of green energy as a source. Recently, usage of electrical energy is replaced by solar energy at various equipments. Solar desalination method has been evolving in various countries. A thermal storage system is designed that converts the sea water in to pure water with different PCM materials. Performance is monitored with respect to the time in Hour/Min/Sec and level of water in mm, PV cell and humidification. Latent heat storage solar system is integrated with the solar water desalination and the values are gathered and analyzed in the SCADA system. However, the very low conventional efficiency of the system throughout the discharging process very close to one to another process, and also perfected commercial grade paraffin values. The experimental results used to examine the accuracy of the PCM materials find in convective heat transferred by the flowing fluid in the axial directions.

KEYWORDS: Solar Energy, Distillation, Experimental Study & Apply PCM Materials

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INTRODUCTION

Various research works have already been carried out to increase the productivity of the conventional mono basin solar systems where increased output is achieved through sand, pebbles, vacuum technology, flat plate collector and hot water storage tank [1]. studies have also been made in the conventional system without modification to clean, refine and purify the water. Various researches are in progress that studies the applicability of solar energy in various places and its deployment places. There are also works that were conducted in the reservoir for accumulating and storing solar energy. Research has also been made in the usage of fins, effluent treatment, and solar stills. The following figure 1 represents the consumption of the renewable energy globally.

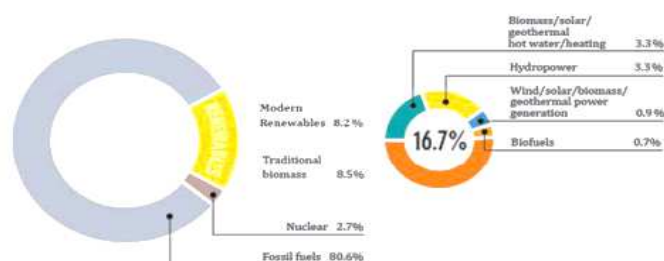


Figure 1: Global Resources Performing in Various Country's

With the advent development in all the nations, energy is the most essential resource. Energy plays a vital role in different applications either it be it in the form of domestic consumption or industrial usage. Various sources in the form of renewable or non renewable are available. Water is a main source of energy with its vast usage in various other applications. According to a survey, only 30% of the total mankind in consuming purified drinking water. This situation prevails in India also where the case is worse in the north regions. It is obvious that the survival of the mankind very much depends on the water. It is most crucial resource to the mankind. Studies has also depicts that 65-75% of the total surface of the earth is covered with water. But, only 2.5% of the total available water is useful to us. 97% of the total water is in the form of sea water and some in the form of ice in the region of artic and antarctica. With this smaller percentage of the water resource the survival of the mankind is the big issue. The other thing that has to be considered is the utilization of the water by the various industries. It is a known fact that the consumption of water by industries for production of various goods is high. With the introduction of new industries this becomes more tremendous. The thing that has to be considered is the enormous amount of polluted water that comes out as wastes from theses industries. Industries consider the effluent management as a major issue. This issue has been considered and experimentation was made to desalinate the effluent coming out of the industries and salt water through solar desalination technique. In the conventional solar desalination process, the productivity of the solar collection in case of less gallons of water could not be managed due to various uneven parameters such as temperature, absorb area, surface reactive water, temperature inlet and outlet and depth of water. In this system the surface area of the water is increased [01].

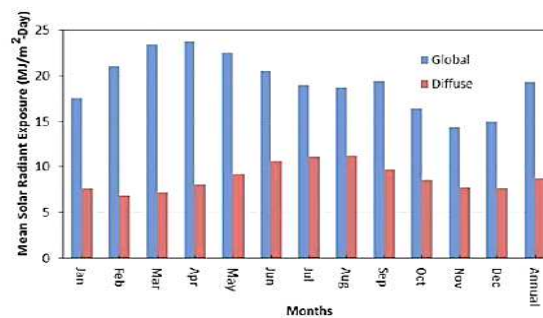


Figure 2: Mean Monthly Solar Radiant Exposure in Chennai, India (Source: TWAD, Tamil Nadu)

The productivity of the purified water is increased with the increase in the surface area. Productivity is increased with the conversion from the mini scale to the maximum scale of the solar still [02]. The materials that are currently being used in the solar still to increase productivity are sand, black rubber, coconut fiber and reinforced fiber. Sponge and fin are found to produce better results in some cases and some other results reveal that sand increases the productivity. In the experimentation done, various PCM materials are used the experimentation was made with different weights ranging from 20g/Kg to 80G/Kg. it is natural to get blockings in the pipe due to high concentration.

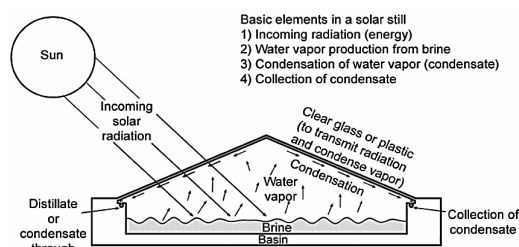


Figure 3: Present Experimentation of Solar Desalination System Works

Theoretical analyses were made to solve the basic energy balance equation in polynomial calculation to deliver different results. Tamil Nadu water supply and drainage board [TWAD] a government sector of tamilnadu, India installed high storage systems of water in various parts of Tamilnadu[4]. The mean solar radiation exposure in Chennai is shown in figure 2

The demand for the energy increases worldwide every day. Renewable energy would play a vital role in meeting this demand. The projected demand in the year 2020 is more tremendous. The solar desalination process is depicted in figure 3. The solar desalination system can be used in anywhere such as in ship, commercial buildings, residential buildings etc. solar system uses minimal consumption with maximum resource production. The experimental system presented is designed in such a way that 70 % of the system is conventional and the remaining 30% uses modern technologies. Analysis of various scientific papers reveals that thermal storage systems are suitable to minimize the difference between the energy supplied and produced. The designed system desalinates the sea water to pure water with the thermal storage system.

LITERATURE SURVEY

In the world economy study, fabrication of a solar collector is made and examined the results obtained at various climatic conditions that prevail in Chennai, tamil nadu. India [05].this is designed in such a way that the purification process is economical and with nil chemical composition to get high humidification. The various solar system methodologies for solar collection and thermal storages is given in the following figure 4

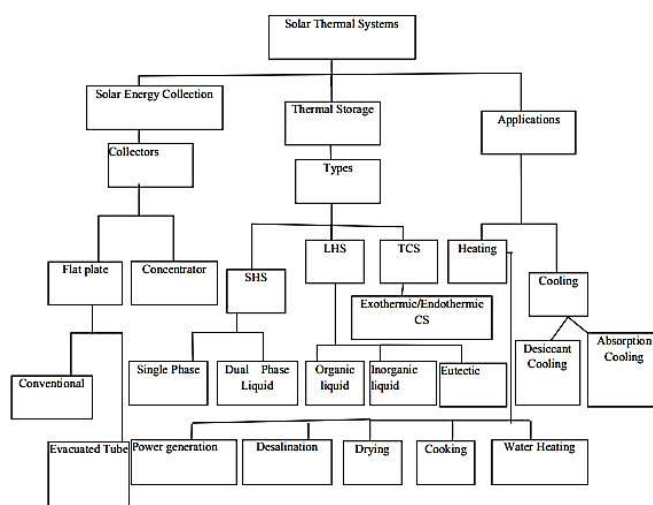


Figure 4: Classification of Solar Thermal Systems

[06]The phase change materials are chosen and are encapsulated in to different types such as ball type, rectangular type , different grades and different shapes to train in various resource areas. Various slopes, baffles are fabricated to to increase the retention time of water with solar radiation. With this experimentation of various materials in the solar basin formation of pathogenic organism is observed for various models and it is used for the performance of the solar collector and monitoring the evaporation heat co-efficient.

The scientific paper studies the retention time for the yield of more water through different passages such as the baffles and basins. Collection and formation of pathogenic organisms is also studied. Dunkles model is used for calculating the heat transfer coefficient for years. Recent surveys show that various other models such as RHN-model maximizes the

accuracy than the dunkles model. A new RHN [Ravi-Harris-Nagarajan] model is derived for finding the maximum average water temperature in the basin [07]. The water thermal heat can be worked out with different cascaded methods and stepped baffles without storage heat solutions. The TES is [Thermal Storage System] is one of the appropriate system and methods and techniques which addresses the mismatch that occurs between the most demand energy resources in solar systems. This paper examines the latent heat storage systems storage and its challenges. The system is without thermo chemical reactions. Without liquid following improvement of heat sources [08].

There are certain constraints that prevent the implementation of effective heat transfer or latent heat storage system designed with the renewable resources. The commercial value of the PCM materials depends on the market availability and demand. It has its own impact in the designing of the low economic systems. Various application sectors are to be identified that can utilize the latent heat storage systems. Examinations were made in clean water, cost free techniques to gather it. The desalination process shows the most performing method. As oer the past study, the classification of the different storage systems are 1. Mechanical 2. Chemical 3. Magenta 4. Thermal storage system [TES] 5. Biological. Thermal storage systems are found to be more cost effective in terms of maintenance, flexible and with indoor air permeability. The pollution emissions are also low in these systems.

DISCRIPTION OF SOLAR SUPER DISTALINATION EXPERIMENTAL SETUP [SRDE]

Conventional Latent Heat Storage System

Latent heat is the heat generated or absorbed at a fixed temperature process. State changes would result in latent heat. Latent heat storage can be done with a state changes among liquid, fluid or gas. Solar systems are the main focus of this and this is the place where there is less discharging of the water and could be applied to various sectors. Paraffin wax and non-paraffin artificial components could be used as the latent heat storage materials in these systems. Equation of the heat transfer fluid is used for the determination of transfer of heat from the sources to the storage. Many researches have been made in identifying the various applications of this model. PCM materials are the storage materials.

Phase changing materials are used in most of the latent heat storage systems. The source of the temperature, operating modes, temperature range, high latent heat and congruent melt are to be considered. The selection of the phase changing material depends on various factors. PCM melting temperature, range of the discharging of operating fluid temperature, latent heat, volume fraction of the quality of the solar energy resources are considered. Various applications based on the congruent melting of the phase changing materials are also available. The mostly identified applications of PCM are the applications related to the thermal storage. Studies have also been made in the transportation of values that are permissible in the food processing, which plays a major role in the form of refrigeration in domestic applications.

Problems Define

Studies have shown that, earlier PCM are used experimentally for prototype development. An insulated cylindrical tank is fabricated to encapsulate it. Different results were inferred by varying the parameters and characteristics of the capsule PCM. The problem that has been noted in various works is the change of the sensible heat in to high temperature. Paraffin wax was used as the phase changing material and the air flow is also considered. After the dissolving procedure the PCM state change is observed which would have been stimulated numerically.

A key study addresses the issues related to the procedures that have to be made with respect to the volume change during the course of the hardening procedure. The impact during rehashing is also studied. Due to the poor conductivity,

permeability and releasing procedure this material cannot be used initially. The desalinated heat transfer will maximize the materials in non uniform characteristics in this storage tank.

Modeling of Thermal Storage Systems

Most of the significant reports concern with the material of the storage system. It considers the latent heat and method of improving the material used in the experimentation, since it involves humidification at different temperatures. Investigating of the issues with the high temperature is a major task. The experimentation is done in three levels. The first level allows the flow of salt water in to the storage tank and the fluid flow into the evaporation tank. The second level of design involves three partitions inside the outer frame. The frame is constructed with a mild steel material. Variants of the system may demand more complex and multidimensional nature. The performance of the practical modeling of the substantial system is very much needed. Thermal storage of the heat is made in medium solar. The inout and the output of the experiments are analyzed by sensors. Performance depends on the factors such as humidity, photovoltaic values and thermal conductivity of the materials. The inner dimension of the tank measure 600 mm X 300 mm. the height of the tank is 200 mm. the conventional drain level is 10 liters. The paraffin wax in the form of spherical capsules is filled in different partitions of the PCM materials. The materials such as CPCL paraffin wax, HS58, Solid type wax are procured from pluss poymer Ltd. The system is shown in the figure 5 which depicts that the spherical capsules are surrounded by water which acts as the latent heat storage of the system. A glass is placed above the perforated plate which ensures the high thermal mass and flow storage. The spherical capsules are filled to a height of 200 m above the plate.

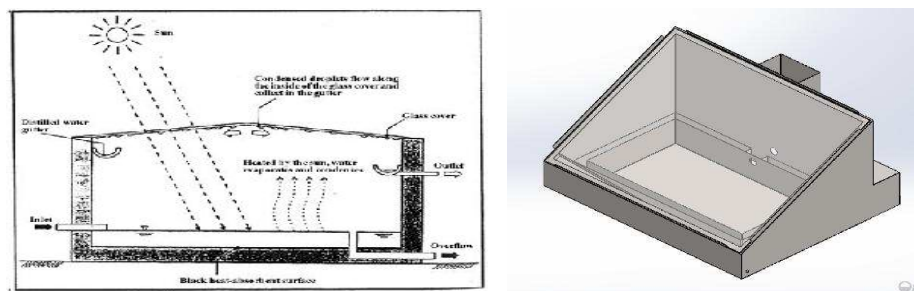


Figure 5: Straight Through Advanced Solar Salt Water Desalination with Generation System

Table 1: Specifications of the Solar Radiation Water Desalination System [SRDE]

S. No	Specification Frame		Specification Material		Specification Fluid Ranges	
	Description	Dimension	Description	Dimension	Description	Dimension
1	Aperture length(LC)	1.4m	Absorber material	Copper	Inside diameter (Di)	0.0254m
2	Aperture width (W)	0.9m	Absorber length	1.4m	Outside diameter (Do)	0.027m
3	Focal distance (f)	0.3m	Intercept factor	0.9	Absorber tube emissivity	0.9
4	Aperture area (Aa)	1.8m ²	Mode of tracking	manual	Specular reflectivity of concentrator surface	0.9
5	Rim angle (Ør)	15°	Collector axis	N/s horizontal	Working fluid	Water
6	Straight through material	0.001m	Observing material1	PCM [wax-graded]	Mass flow rate	0.017 kg/s
7	Concentration ratio	11.46	Observing material2	Black graded wax	Reflective material	Black coated Glass
8	Tilt factor	1.0143	Observing material3	Polymeriene wax	Working monitoring system	LabVIEW

MATERIAL AND METHODS

Phase Change Materials

In the illustrated PCM, Inaccuracies would have occurred due to the non representational and hypothetical approach followed. The data that are remotely sensed from the observed location are available only at large scale is used for computing the evaporation loss. This is the reason behind the inaccurate result obtained with the equation of penman on open water. But, it has to be noted that estimation of different structures shown in the following figure 6 becomes possible only with this data.



**Figure 6: Phase Change Materials in
[a] Paraffin Wax [b] Copper Brown Wax [c] Dark Red Wax**

Performance Analysis

The experiment is conducted to analyze the whether the time taken to purify the water is less. During the experiment the heated thermal flow is allowed to pass through the taper flow solar collector and the top storage tank. The experiment was conducted in two sessions, one during 6 A.M to 6. P.M and another from 6.P.M to 6.A.M . The former session considers the humidity and photovoltaic of the storage system whereas the later session examines the intensity of the solar radiation along with the ambient temperature. When most of the states of art technologies are conducted to check the new model systems, the proposed approach uses SCADA programming to analyze the results. It gets the input from the actuation system integrated with the sensor. The setup is shown in the figure 7. The humidification and the stratification will be monitored by the system continuously. Ambient temperatures were measures and the flow rate is measured with the flow meter the accuracy of which is 0.75. the intensity of the solar radiation is measured by analytics flow method.

$$S = I_b R_b \rho \gamma (\tau \alpha)_b + I_b R_b (\tau \alpha)_b \left[\frac{D_o}{(W - D_o)} \right] \quad (1)$$

Useful heat gain rate from (6)

$$Q_u = F_R (W - D_o) L \left[S - \frac{U_L}{C} (T_f - T_a) \right] \quad (2)$$

Flushing of SRDE system is the initial point of the experimental work. Water is allowed to flow and fill the system. The rate of is set to a specified value. Quasi steady state is attained after allowing the SRDE to run for 30 minutes. The following things have to be ensured for correct observation, Connection between the indicator of the temperature and temperature sensor, solar power meter, anemometer and tracking mechanism of straight channel. In order to ensure the natural flow, the SRDE is placed just above the collector level. It is depicted in the following Table 2.

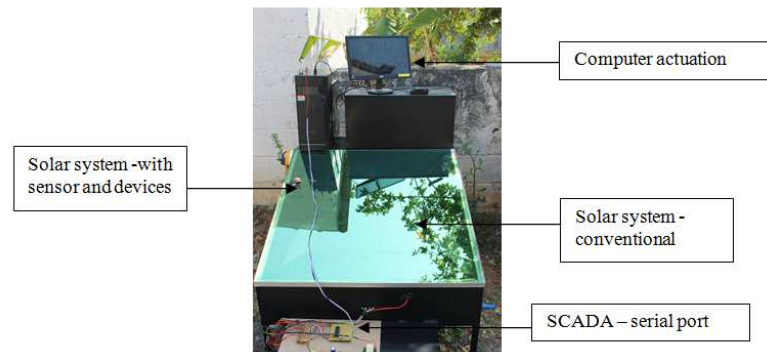


Figure 7: Water Desalination System in Experimental Setup

Expectations Experimental Research Works

- The present research works flows in modeling of PCM based on bed storage system analysis in heat transfer fluids has been evaluated in advanced super system.
- The designed work models the PCM based storage system.
- The latent heat storage problem is solved which results in the high conductivity of the system
- Experimentation and examination has been made in the design in which the system is integrated with the traditional approach
- The time consumption is reduced and the performance is improved
- Heat storage at different latent heat of pcm materials Versus the water level is found at different sessions.

Table 2: Advanced Solar Desalination System Performance Analysis Report for Different Places /Time

Avg time to capture 0.25 gal distilled water	Time per		Sunrise	Sunset	Time Solar Radiation		Average Output per day	Efficiency Comparison to Solar Radiation Values
			gal					
date	min	Hr	Hr			Hr	Gallons	%
16-Oct	38	0.63	2.53	6:16	19:34	13:18	5.25	46.5
31-Oct	33	0.55	2.2	7:15	17:10	10:59	4.99	44.22
31-Oct	43	0.72	2.87	7:15	18:14	10:59	3.83	33.93
13-Nov	56	0.03	3.73	4:34	18:14	15:18	4.1	36.3
14-Nov	62	1.03	4.13	4:36	19:52	15:15	3.69	32.68
20-Nov	36	0.6	2.4	4:36	19:51	15:15	6.35	56.26
22-Nov	40	0.67	2.67	4:47	19:51	15:04	5.65	50.04
23-Nov	36	0.6	2.4	4:43	19:51	15:02	6.26	55.49
24-Nov	44	0.73	3.2	4:43	19:15	15:00	5.11	45.2
24-Dec	48	0.8	2.8	4:44	19:44	15:00	4.69	41.51
25-Dec	47	0.7	2.91	4:44	19:44	13:18	4.75	47.07
Average Mean	43.909	0.642	2.895				5.3201818	44.47272727

RESULTS AND DISCUSSIONS

The number of days taken to experiment and simulate the sytem of heat storage with various ambient temperatures

is minimal. The ambient and humidification value ranges from 31°C as minimum and 34.2°C as maximum. The variation in the internal temperature for the test time towards the analysis of temperature is shown in Figure 1-2 . it is observed from the experimentation that the variation in inlet temperature ranges from 29°C-33°C. As specified earlier the observation was made using SCADA. The light intensity of the solar radiation and absorber temperature are the deciding factors of the changes in the outlet temperature. The temperature either increases or decreases with this factors. The maximum level of the outlet temperature recorded is 70°C whereas the recorded minimum level is 34°C. There is a heavier convective heat lose when the receiver is exposed to humidification for discharging of water to determine PH Value. The values used for calculating the receiver temperature is the average of three values rather over the space rather than the time.. 78°C-145°C is the range of the absorber temperature. The recorded beam radiation with reference to the test schedule is given in Figure.5-7. The observation lighting value for recording beam radiation is 400-800 W/m². The results clearly depicts that during the first day of the test, the radiation value reaches a maximum value of 800 W/m² at 13.00 hours and there is a down trend towards 400W/m² at 16.00 hours. The values of the solar flux and valuable heat gain variation during the examination period are given in the figure 8 and 13 .the range of the solar flux is between 307-614 W/m². This will result in increase of absorber temperature and valuable heat gain with respect to the solar radiation. It is obvious that with the increase in solar radiation the receiver temperature also increases. It is also been noted that, throughout the day, the heat extended from the water flows through the receiver. The factors that affect the increase in heat are receiver temperature, wind speed and solar radiation. The hourly averages of inlet temperature, outlet temperature, absorber temperature, beam radiation, solar flux and useful heat gain is given in Figure 14 -16. This gives the correlation between various attributes specified above both in hourly and daily basis.

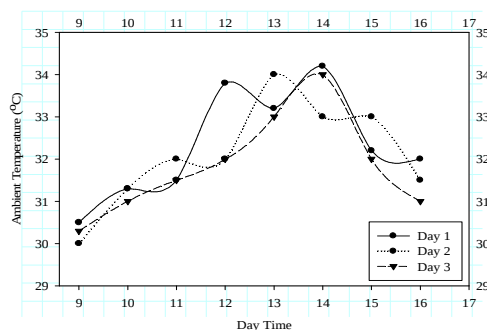


Figure 8: Variation of Ambient Temperature with Time

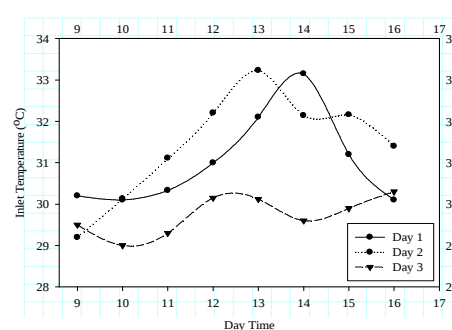


Figure 9: Variation of Inlet Temperature with Time

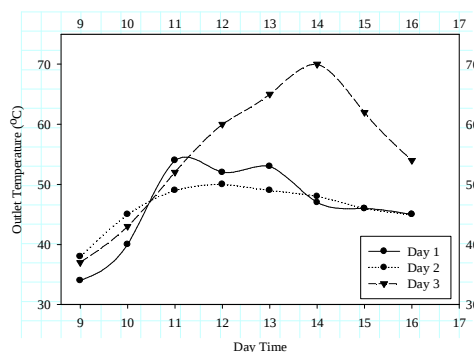


Figure 10: Variation of Outlet Temperature with Time

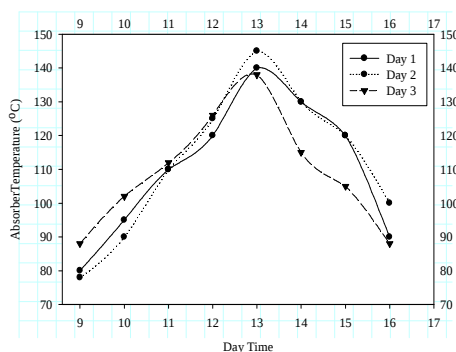


Figure 11: Variation of Absorber Temperature with Time

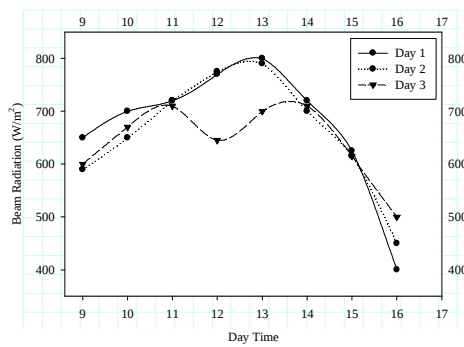


Figure 12: Variation of Beam Radiation with Time

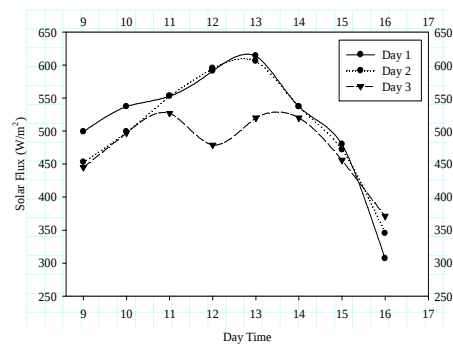


Figure 13: Variation of Solar Flux with Time

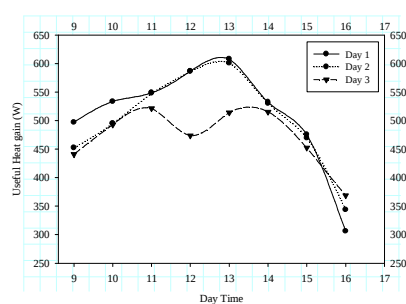


Figure 14: Variation of Useful Heat Gain with Time

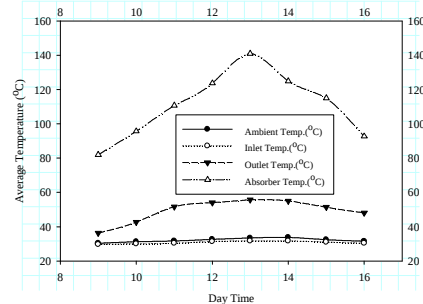


Figure 15: Average Variation of Ambient, Inlet, Outlet and Absorber Temperature with Time

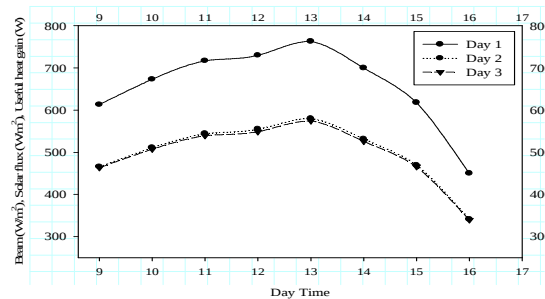


Figure 16: Average Variation of Beam Radiation, Solar Flux and Useful Heat Gain with Time

CONCLUSIONS

The following points summarize the results obtained.

- The results obtained with the experimentation conducted with the most effective and advanced system with varying PCM temperatures is analyzed.
- Comparative performance enhancement is achieved with the conventional system. Betterment is achieved with the usage of HC58 paraffin wax.
- Desalination is improved with the minimal mass flow. Since the collection efficiency is high and power consumption is low, the system is highly recommended.

- The inlet of the water level system of sea water has a major role in improving the classification performance and valuation of LHS system.

Future Works

- Analysis of performance enhancements in desalination systems under discharging conditions
- Numerical analysis of the designed system would be of a great challenge and will be addressed in the future
- Study of variation in performance with the variation in the coordination and the flow of fluid or solid state of the PCM and changes in the inlet and outlet geometrically can be made.

NOMENCLATURE

Abbreviations

Q_u	- Useful heat gain rate (W)
F_R	- Heat removal factor
W	- Width of collector (m)
L	- Length of the collector (m)
D_i	- Inner diameter of Absorber (m)
D_o	- Outer diameter of Absorber (m)
C	- Concentration ratio
T_{fi}	- Fluid inlet temp ($^{\circ}\text{C}$)
T_a	- Ambient Temperature ($^{\circ}\text{C}$)
T_r	- Receiver temperature ($^{\circ}\text{C}$)
I_b	- Incident beam radiation (W/m^2)
S	- Solar flux (W/m^2)
R_b	- Tilt factor
m	- Mass flow rate of fluid (Kg/s)
C_p	- Specific heat of the fluid ($\text{J}/\text{Kg } ^{\circ}\text{C}$)
A_r	- Surface area of the receiver (m^2)
F'	- Collector efficiency factor
h_r	- Heat transfer co-efficient due to wind ($\text{W}/\text{m}^2 ^{\circ}\text{C}$)
h_i	- Convection heat transfer co-efficient ($\text{W}/\text{m}^2 ^{\circ}\text{C}$)
U_L	- Loss of co-efficient ($\text{W}/\text{m}^2 ^{\circ}\text{C}$)
U_O	- Overall heat transfer co-efficient ($\text{W}/\text{m}^2 ^{\circ}\text{C}$)

- K_t - Thermal conductivity of tube material (W/m C)
 K_w - Thermal conductivity of fluid (W/m C)
SRDE - Straight Trough Solar Desalination experiment
PWR - Pure Water Reservoir Tank

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